Chapter 2

Operation and Management of a Public Water Supply

Key to the successful operation and management of a public water system is the knowledge of individuals about their job responsibilities. Knowledge is a tool just as are wrenches and computers. Each individual must be given the proper tools to get the job done right.

2.1 Management of public water systems

Management of a water supply involves five elements:

- Organizing
- Planning
- Financing
- Maintaining
- Adhering to the laws, regulations and practices of the profession

2.1.1 Public water systems usually are organized as municipally- or privately-owned.

2.1.1.1 Municipally-0wned

A municipally-owned water system is a public water system that is owned and operated by a local government or urban political unit with corporate status. The property owners or voters are substituted for the stockholder of a privately owned system. Examples would be water systems owned by cities and towns. Normally the mayor or water board is the policy-making body.

2.1.1.2 Privately-owned

One or more private investors own a private water system. This could be an individual, partnership, corporation, or other qualified entity, with the financial backing provided by one or more investors. Control over operations may be under the direct supervision of the owner or accomplished through an elected board of directors and its directives carried out by the president. These organizations may be for-profit or not-for-profit.

2.1.2 Planning

Organization planning is the development of a structure that will enable people to work together effectively to accomplish their goals and objectives. This structure must be designed so that daily needs are met along with future needs. This plan must be periodically evaluated to make sure it is still meeting the needs and objectives. Periodic changes probably will be needed.

2.1.3 Customer Relations

Customer relations are the means to promote good will and understanding between the water supplier and its customers, thereby developing a favorable public image.

The employees have the greatest influence on the water supplier's public image. Their ability to supply safe water in both quality and quantity at a reasonable pressure, along with courteous and intelligent handling of customer requests and complaints, will greatly affect this image. Remember, a complaint is an opportunity to improve your image if handled correctly and in a professional manner. Common concerns of customers are water quality (taste, odors and turbidity), low or high pressure, all types of water leaks and high water bills.

2.1.3.1 Protection of Public Health

The most important responsibility of a water supplier to protect the public health by providing water that is free of disease and toxic chemicals. All the laws and regulations require this but it is still up to the water supplier to make sure it happens. There are many tools at the water supplier's disposal to accomplish this.

First, there is a Wellhead Protection regulation to protect the source of water.

Second, there are a multitude of tests to verify the quality of the raw and finished water. Then there are many different types of water treatment that can purify the water to improve the quality so that it can meet the regulations, laws and needs of the customer.

Third, disinfection is critical in meeting safe drinking water. Chlorine has been for many years the main chemical to make sure drinking water is free of any pathogenic bacteria by killing these bacteria. Chlorine has also allowed the water supplier to carry a chlorine residual in the water distribution system to kill any other bacteria that might enter the distribution system later. There are other disinfection chemicals and water treatment processes that are available to accomplish the same result. Every water system is different and the water supplier will need to choose the process that works best for them.

Fourth, cross connection (backflow) control helps prevent possible contamination from customer piping systems. Cross connection control is typically implemented with approved check valve assemblies that do not allow water to flow backwards from the customer's plumbing into the public water supply.

2.2 Finance

Every water system requires proper financing to be a viable operation. Citizens of a community or private investors may provide initial financing. To continue to operate, however, a system must be supported by an adequate rate structure that meets current and future needs.

2.2.1 Rates

In providing adequate water service to its customers, every water utility must receive sufficient total revenue to ensure proper operations and maintenance (O&M), development and perpetuation of the system, and preservation of the utility's financial integrity. Nearly all of total revenue requirements for most utilities are met from revenue derived from selling water to their customers. Other revenue not derived from the sale of water may come from a variety of sources such as rentals, merchandising, and providing services to other utilities or entities, and capacity or impact fees.

It is important to ensure that a rate or rate structure is consistent with applicable local, state, and federal laws before it is implemented. The implementation of a rate structure that may be prohibited by or is inconsistent with laws or statutes puts the utility at unnecessary risk. All relevant laws that could affect the use of a particular rate alternative should be evaluated by the utility.

Laws and regulations may be significantly different for governmental water utilities than for investor-owned water utilities. They may, however, be quite similar for government-owned and investor-owned utilities regulated by the same public service commission. Water utilities are typically required to submit their proposed rate tariffs to state regulatory agencies for review and approval. In most cases, the laws, regulations, and procedures are usually well defined for the utility to comply with and follow in identifying revenue requirements, allocating costs, and designing rates.

2.2.2 Rate Structures

Financing and rate setting can be very complex and critical to a water utility. Therefore, a listing of the different types of rates that could be used is as follows:

- Lifeline Rates & Low Income Discounts
- Inverted Block Rate
- Declining Block Rate
- Uniform Volume Rates
- Economic Development Rates
- Off Peak Rates
- Seasonal Rates
- Negotiated Contractual Rates
- Marginal-Cost Pricing
- Indexing or Indexed Rates
- Rate Schedules by Customer Class

2.2.3 Rate Approvals

Once the rate structure has been determined by the local governing body, normally through a rate ordinance, a filing of the ordinance with the rate tariff will need to be filed with the State Regulatory Commission. This will only be done if the water utility comes under the Regulatory jurisdiction. Some utilities have opted out of this jurisdiction and rates are approved at the local level.

After the Rate Ordinance has been filed with the Regulatory Agency, there may be a number procedural steps that will take place prior to the approval and initiation of the rates. Basic procedural steps that may take place are:

- The initial filing of rate and charges
- Prefiled testimony of the petitioner –
- - Superintendent
- - Engineer
- - Rate Consultant / Accountant
- Initial Public hearings
- Discovery and information gathering by the Public
- Settlement Agreements between Petitioner and Public
- Final Hearing
- Approval
- Initiation

Note, these are basic steps to give the water utility a general understanding of what may be required when going through the regulatory commission. Further, if a Bond Issue is required, then there will be additional steps the Water Utility and the Regulatory Commission will need in order to finalize the rates for approval.

2.3.1 Operator Responsibilities

A certified operator is morally and legally responsible to provide a safe water supply used for human consumption. The certified operator must remember the importance of water to the community and produce it in the most efficient, reliable and economical manner.

The operator deals with the water system every day and is responsible for giving the best service possible at all times. You are the first contact the public will make. You must not only know and apply critical water distribution techniques, but you must conduct yourself in such a manner that the public is confident that the service is performed properly.

Almost everyone in a community takes the water for granted and expects safe and sufficient quantities and adequate pressure. This is largely because of the efforts of the professional water operator. Most often water is the least expensive vital resource available.

Safeguarding the quality of water is becoming increasingly important. Your daily activities can greatly influence the quality of the water that is delivered. Requirements will need to be met now and in the future as new rules are constantly being added.

An operator must always be alert for possible events that could contaminate the water. Cross-connection and backflow situations are always a concern.

An operator is a vital person to provide "WATER FOR PEOPLE."

2.3.3 Groundwater Supplies

Water supply for Public Water Systems in Indiana is about evenly divided between ground water and surface water in terms of gallons pumped, but there are many more ground water systems than surface water systems. Obviously, ground water systems on average are smaller in capacity than surface water systems.

Any groundwater supply with a withdrawal capacity of more than 100,000 gallons per day (GPD) must be registered as a Significant Water Withdrawal Facility with the Indiana Department of Natural Resources.

The total developed groundwater source capacity should generally equal or exceed the designed maximum day demand and equal or exceed the designed average day demand with the largest producing well out of service.

Schools, correctional facilities, health care facilities, and agricultural labor camps, regardless of pumping capacity, must have at a backup water well(s) to meet the “largest producing well out of service” requirement, i.e., a minimum of at least two wells.

2.3.3.1 Well Disinfection

Current design and construction rules for Public Water Supplies (327 IAC 8-3.4-24) require the following disinfection procedures, which shall be performed with calcium hypochlorite or sodium hypochlorite:

- Gravel installed in a new production well for gravel pack must be chlorinated by use of hypochlorite prior to installation in a well at a rate that will produce a liquid concentration of at least 50 milligrams per liter (mg/L) as the gravel is installed. As an alternative, chlorine shall be added to the well and circulated until a chlorine concentration of not less than 50 mg/L in the entire volume of fluid in the well bore is achieved.

- Permanent equipment and material used in a production well shall be chlorinated prior to installation by spraying exposed areas with a solution containing a chlorine residual of not less than 200 mg/L.

A new or modified well proposed to be a production well should be chlorinated according to one of the following methods:

1. The water in the well casing shall be treated for disinfection to create a minimum chlorine residual of 100 mg/L in the entire volume of water in the casing, well screen, and rock hole, if present. The well must be chlorinated using the amount of chemical compound in the table below, and the well must be surged at least three times following chlorination. The chlorinated water must then remain in the well at least 12 hours following the surging activity.

2. The water in the well casing shall be treated for disinfection to create a minimum chlorine residual of 50 mg/L in the entire volume of water in the casing, well screen, and rock hole, if present.

3. The well shall be chlorinated using the compound requirements in the table below, and the well must be surged at least three times following chlorination. The chlorinated water must then remain in the well casing at least 24 hours following the surging activity.

Amount of Chemical Compound

Well-Hole or Well Casing Diameter (in.)	Volume per 100 Feet of Water Depth (Gallons)	Calcium Hypochlorite* (65 percent available Chlorine)	Sodium Hypochlorite** (12 percent trade available Chlorine***)
5	106.09	1.1 oz	5.65 fl oz
6	146.9	1.5 oz	7.8 fl oz
8	261.1	2.7 oz	13.9 fl oz
10	408.0	4.2 oz	1.4 pt
12	587.5	6.0 oz	2.0 pt
16	1,044.0	10.7 oz	3.5 pt
20	1,632.0	1 lb 1 oz	0.7 gal
24	2,350.0	1 lb 8 oz	1.0 gal
30	3,672.0	2 lb 6 oz	1.5 gal
36	5,287.0	3 lb 6 oz	2.2 gal
48	9,400.0	6 lb 1 oz	3.9 gal
60	11,690.0	9 lb 7 oz	6.1 gal

Notes:

* Quantities of Ca $(OCl)_2$ based on 65 percent available chlorine by dry weight (16 oz = 1 lb).

** Quantities of NaOCl based on 12 trade per cent available chlorine by U.S. liquid measure (1 gal = 4 qt = 8 pt = 128 fl oz).

*** Trade percent is a term used by chlorine manufacturers; trade percent x 10 = grams of available chlorine in 1 liter of solution.

After disinfection is accomplished as indicated above, a new or modified public water supply system production well, including flowing wells, shall be sampled for the presence of coliform at least twice, with sampling done no less than 24 hours apart. The sample shall be examined by a laboratory certified by the Indiana State Department of Health. If the presence of coliform is indicated by the sample results, the disinfection of the well shall be repeated.

Disposal of chlorinated water from well disinfection shall be to a sanitary sewer with the approval of the local sewer authority, or to a location other than a sanitary sewer in accordance with local, state and federal regulations.

2.3.3.2 Well Maintenance

Maintenance of water wells can be summarized very simply: Take care of the well and pump equipment before they become unreliable or inoperable.

Groundwater chemistry and biology issues, physical issues and pumping/over-pumping issues all affect the need for well maintenance. Biological activity reaction tests (BARTs) can give an indication of biological fouling, including iron bacteria, slime forming bacteria and sulfate reducing bacterial. Particulate matter, such as sand, also is an indication of problems.

Physical and biological changes occur around the well as a result of the increased movement of water toward the well. These changes eventually will cause plugging and clogging of the well, resulting in decreased production and/or lowered pumping water levels in the well.

Static and pumping water levels should be measured at least every six months, with one set of the readings to be made during the peak-pumping season.

Maintenance test pumping, including readings of static and pumping water levels and determination of specific capacity (SC) should be accomplished at least every two years for all Community Water Systems, Noncommunity Nontransient systems and susceptible populations, which includes schools, correctional facilities, health care facilities and agricultural labor camps. Noncommunity Nontransient systems should have maintenance test pumping at least every four years. (Specific capacity is calculated by dividing the production of the well in gallons per minute [GPM] by the feet of drawdown between the static water level and the pumping water level. Water levels need to stabilize before measurements are made. The GPM should be the normal production rate of the well and pumping equipment.)

The SC needs to be recorded and plotted against time. Normally, the SC holds steady during the early stages of a well's life, followed by a period of slow decline, and finally a sharp drop-off as the flow paths around the well close off. But there are many exceptions to this pattern. For example, it is not uncommon in limestone wells to see the SC increase as new flow paths develop. In determining the change in SC, the percentage change, not the absolute numbers, is important.

Recent research published by the American Water Works Association emphasizes the importance of knowing the SC. If the SC drops too far below the original SC, the full capacity will likely not be recovered with well rehabilitation. AWWA published SC guidelines can be summarized as follows:

> Full recovery of capacity is probable with normal rehabilitation work if the current SC is greater than 85 percent of the original SC.
>
> Full recovery of capacity may be possible, but more extensive (and expensive) rehabilitation work will be needed if the current SC is less than 85 percent of the original SC but greater than 60 percent of the original SC.
>
> Full recovery of capacity is unlikely if the current SC is less than 60 percent of the original SC.
>
> The well may be unsalvageable if the SC drops below 40 percent of the original SC.

It is important that rehabilitation work start before the well's SC falls below 85 percent of the original value, according to the AWWA publication. Doing the rehabilitation work at this point increases the chance of success and reduces the amount of work (and cost) necessary. This is a critical factor if the capacity is to be recovered repeatedly in a cost-effective manner.

2.3.4 Surface Water

Surface water is the major source for public water supply systems. This is because large cities draw most of their water from surface reservoirs. About three out of every four people in the US drink water that originated from surface water sources, so it is important for you to have a thorough understanding of the factors that influence surface water flows.

Surface waters come from two sources:

- Precipitation
- Ground water

When rainfall reaches the ground it either infiltrates the soil, evaporates into the air, or runs off as surface water. But rainfall is not the only form of precipitation that results in surface water runoff. Snow, which may remain on the ground for many months, eventually melts and also contributes to surface water runoff. In portions of the western US, melting snow produces the major part of the annual runoff.

If rainfall were the only source of surface waters, then all streams and rivers would dry up shortly after a rain; however, many streams and rivers flow throughout the year. This is due in part to snowmelt and in part to ground water that enters streams and rivers from springs and seeps.

Just as ground water can give up water to a stream, streams give up a portion of their flows to recharge ground waters. There are a variety of factors that affect surface runoff. Perhaps the most significant are:

- Rainfall intensity
- Duration of rainfall
- Soil composition
- Soil moisture
- Slope of the ground
- Vegetation covering the ground
- Man-made influences

Slow, gentle rainfalls usually produce very little runoff. There is plenty of time for the rain to soak into (infiltrate) the soil. However, as rainfall intensity increases, the surface of the soil becomes saturated. Since a saturated soil can hold no more water, further rainfall builds up on the surface and begins to run off, creating surface water flow.

Man-made influences have a decided effect on surface water runoff. Dams control it; channels, canals, and ditches divert it; and streets and other paved areas increase it.

After surface water runoff has been produced, it flows in the path of least resistance. It begins to form rivulets, which will often then flow into brooks, creeks, and rivers. Each rivulet, brook, creek, and stream receives water from an area of land surface that slopes down toward one primary watercourse. This drainage area is known as a watershed or drainage basin.

Within a watershed, there are two types of surface waters: (1) Watercourses, and (2) Water Bodies. Watercourses convey surface waters from higher elevations to lower elevations. Typical natural and man-made watercourses include:

Natural	**Man-Made**
Brooks	Ditches
Creeks	Channels
Streams	Canals
Rivers	Aqueducts

Natural watercourses may flow continuously or only occasionally. Continuously flowing streams are called perennial streams. These streams are supplied both by surface runoff and by springs and ground-water seepage. Streams flowing only occasionally are called ephemeral streams. Ephemeral streams usually flow only during and shortly after a rain, and are supplied only by surface runoff.

Man-made watercourses carry water only when man intentionally diverts water to them.

A water body is a water-storage basin. It can be a natural basin such as a pond or lake, or a man-made basin such as a reservoir. Man-made water bodies are built to serve some specific water need. These bodies range from basins for watering stock to massive reservoirs that store water for municipal and recreational use.

2.3.4.1 Reservoirs

The name “reservoir” is ordinarily applied to a basin designed to store water during periods in which the stream flow is greater than the demand and to deliver water during periods when the reverse condition occurs.

Building a dam in a natural valley or canyon usually forms reservoirs, thus developing an artificial lake or pond from which water may be drawn at will to supply the required demand.

Safety, cost, need for water, and the number of sites available are among the factors that will decide the feasibility of any particular site. The selection of a site for an impounding reservoir is predicated upon the fact that the yield of the stream will serve the intended purpose.

The determination of the yield involves the complicated problems of storage, regulation and sanitary features of reservoir sites, their maintenance and their use as recreational centers. All of these need to be investigated.

Since the water quality of reservoirs is dependent upon the runoff from surrounding areas (the watershed), it is important to realize that it is the responsibility of the administrative authority to manage the area in the watershed to assure a safe and adequate water supply. The extent of the area and the responsibility of the administrative authority are governed by federal and state statute. Any question regarding the management of the watershed and/or water quality should be directed to the appropriate governmental authority.

2.3.4.2 Outlet/Diversion Controls

Outlet structures are usually provided in impounding reservoirs to control the release of stored water. In waterworks practice, they are usually considered as intakes. It is frequently necessary to provide outlet works for spillway purposes or for emptying the reservoir for repairs, destruction of plant growth, desilting, etc., or for supplying water to prior rights or riparian (land owner) interest on the stream below the dam.

Design considerations include location, capacity, structural features, and safety. The elevation of the outlet works depends on the purpose of the works and the type of dam. If this purpose is to drain the reservoirs, the outlet must be located at or near the bottom. This is also the case if the structure is to be used for stream control during construction. A position near the base of the earth dam is preferable on account of increased safety from the dangers of percolation and settlement. Safety implies the exercise of sound engineering judgment and ability to assure the adequacy of the structure in the performance of the functions for which it is built.

2.3.5 Clearwells

Clearwells are usually located at the end of a treatment train or at the end of a well or well system. This configuration is used for contact time when chemical treatment additives are used. These storage structures have limited use as storage reservoirs due to their location. Since they are typically located at the end of the well system or of the treatment process, they have limited availability for reliable distribution system supply in case of emergencies. Clearwell storage usually must be pumped and would require standby power to be a reliable resource in case of an emergency.

The most effective use of clearwells is as a contact basin utilized for treatment purposes. The added storage or reserve capability of clearwells are an advantage for operators that need time for maintenance of equipment or structures, but this is not their intended use. Utilities should not rely on clearwell storage as their only means of reserve for the distribution system.

The rated capacity of the process and the contact time necessary to achieve the results of the process are the main focus of clearwell design. Since the purpose of the clearwell is for contact time, the design must assure that short-circuiting does not occur. Adequate mixing and contact time can be achieved by baffling and good placement of the chemical injection points.

Provisions for overflowing and venting the clearwell are important. When designed properly they should exclude the entrance of foreign material and be of adequate size to remove water (waste) in excess of the filling rate. The overflow pipe and/or vent should eliminate insects from entering the clearwell. Vents and overflow pipes should not be susceptible to freezing.

Clearwells should be easily accessible for inspections and cleaning. The design should incorporate means of evacuating accumulations of sludge or settled solids. This can be achieved by the means of sump pumps or areas to gather material washed from the walls and floor. Considerations must be given to the type of concrete and materials used in construction. The clearwell environment can be aggressive due to the addition of chemicals and the water quality. High sulfide containing water can deteriorate concrete and high chemical residuals can corrode metals that may be in the clearwell or in structures above them.

Access to clearwells must be secure from vandals and acts of terrorists by employing locks, fences, alarms and/or other security devices or programs.

Optimum chlorine levels should be maintained to assure that all treatment requirements are met. This is equally true when adding other chemicals. The placement of chemicals in the clearwell should be evaluated for their cause and effect before they are added. Just adding treatment aids at the beginning and/or end of the clearwell does not assure that the optimum results will occur. Retention time, water quality and distribution system residuals will dictate how and when treatment chemicals are added to the clearwell process.

2.3.6 Filtration

Filtration is the most common form of water treatment for Public Water Systems in Indiana, and it usually is preceded by aeration or some form of oxidation prior to the filtration. Various forms and configurations of aerators and filters are used throughout the State, but they most commonly fall into the classes of pressure filters and gravity filters.

2.3.6.1 Pressure Filters

The most common use of pressure filters is for iron and manganese removal. Pressure filters shall not be used in the filtration of surface water, polluted waters or following lime-soda softening. The rate of filtration shall not exceed three gallons per minute per square foot of filter area, except where in-plant testing, as approved by IDEM, has demonstrated satisfactory results at higher rates.

Filters shall be designed to provide for loss of head gauges on the inlet and outlet pipes of each filter, an easily readable meter or flow indicator on each batter of filters and a flow indicator are recommended for each filtering unit.

A minimum of two filter units or cells shall be provided. Where only two units are provided, each shall be capable of meeting the plant design capacity, which normally is the projected maximum daily demand at the approved filtration rate. Where more than two filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service.

Minimum sidewall shell height shall be 5'0". A reduction in sidewall height is acceptable where proprietary bottoms permit reduction of the media depth. Backwash flow indicators and controls that are easily readable shall be provided, along with an air release valve on the highest point of each filter. An accessible manhole to facilitate inspection and repair of the filter tank, means to observe the backwash wastewater and construction to prevent cross-connection shall be provided.

Media for filters shall be clean silica sand or other natural or synthetic media approved by IDEM. The media shall have a total depth of not less than 24" and generally not more than 30", and the effective size range of the smallest material shall be no greater than 0.45 mm to 0.55 mm, with a uniformity coefficient of the smallest material not greater than 1.65.

There shall be a minimum of 12" of media with an effective size range no greater than 0.45 mm to 0.55 mm, and a specific gravity greater than other filtering materials within the filter.

Types of filter media:

Anthracite: Clean crushed anthracite with an effective size of 0.45 mm – 0.55 mm with a uniformity coefficient not greater than 1.65 when used alone. Anthracite with an effective size of 0.8 – 1.2 mm with a uniformity coefficient not greater than 1.85 may be utilized when used as a cap. Effective size for anthracite used as a single media on potable groundwater for iron and manganese removal only shall be a maximum of 0.8 mm.

Sand: Silica sand used for filtering shall have an effective size of 0.45 mm to 0.55 mm, with a uniformity coefficient of not greater than 1.65.

Granular activated carbon (GAC): Granular activated carbon media may be considered only after a pilot or full scale testing and approval of the IDEM. Larger size media can be used if specifically approved and provisions must be made for frequent replacement or regeneration if GAC is used for filtration.

Torpedo Sand: A 3" layer of torpedo sand should be used as a supporting media for filter sand, and should have effective size of 0.8 mm to 2.0 mm and a uniformity coefficient not greater than 1.7.

Gravel: Gravel, when used as the supporting media in a filter, shall consist of hard, durable, rounded silica particles and shall not include flat or elongated particles. The coarsest gravel shall be 2.5" in size when the gravel rests directly on the strainer system, and must extend above the top of the perforated laterals. Not less than four layers of gravel shall be provided in accordance with the following size and depth distribution when used with perforated laterals:

Size	Depth
2.5" to 1.5"	5" to 8"
1.5" to 0.75"	3" to 5"
0.75" to 0.50"	3" to 5"
0.50" to 0.18"	2" to 3"
0.18" to 0.09"	2" to 3"

Note: Reduction of gravel depth may be considered when proprietary filter bottoms are specified.

Surface or subsurface wash facilities are required except for filters used exclusively for iron or manganese removal, and may be accomplished by a system of fixed nozzles or a revolving-type apparatus. Air scouring can be considered in place of surface wash.

Backwash of the filter shall be at a minimum rate of 15 gallons per minute per square foot, consistent with water temperatures and specific gravity of the filter media. A rate of 20 gallons per minute per square foot or a rate necessary to provide for a 50 percent expansion of the filter bed is recommended. A reduced rate of 10 gallons per minute per square foot may be acceptable for full depth anthracite or granular activated carbon filters. Each cell or filter shall be backwashed for at least 15 minutes, and duplicate backwash pumps or a second means of backwash water supply shall be provided.

2.3.6.2 Gravity Filters

Flow rates, backwashing rates and media requirements set out in 2.3.6.1 for pressure filters also apply to gravity filters.

2.3.11.1 Fire Hydrants

The most common function of a fire hydrant is fire protection. The hydrant is the property and responsibility of the Water Department, and during an emergency it is used by the Fire Department. Fire hydrant functions such as water main flushing, construction projects, street cleaning or any purpose other than fighting a fire is outside the primary purpose for which the hydrant was installed. Such use should be controlled by the Water Department, so that the hydrant is in good working condition at all times.

Hydrants should be opened and closed slowly to prevent pressure surges in the mains. These pressure surges can cause a water hammer, which in turn can cause damage to the water mains.

Hydrants in your system should be flushed once a year at a minimum. Additional flushing may be required if there are treatment problems. This allows for hydrant maintenance, which helps keep everything is in good working order.

Hydrant flow tests should be run on every hydrant in the system, so that fire flows are known. The information is vital for further expansion and insurance rating. Always keep records on valve locations and maintenance activities.

2.3.11.1.3 Water Meters

A water meter is a device developed to measure water. Accurate water measurement is the means by which water utilities produce revenue to cover expenses, charge each customer equitably, prevent waste of water, and minimize the load on wastewater facilities. A water meter only does two things: it measures the water passing through and it records the measurement.

There are a variety of styles and types of meters available. The mechanical aspects are different but the principles are the same (measure and record). The most common types of meters used in the Midwest are the positive displacement (both oscillating piston and nutating disc), multi-jet, turbo, compound, fire service, and propeller.

Production meters (meters on wells--for ground water; raw water meters-for surface water; finished water meters--for water leaving the plant or pumping station), which will probably be propeller meters, should be tested on an annual basis. These meters should be tested in place (in their normal meter setting). It is critical that these meters be accurate. These are the most important meters in your system. With accurate production meters the utility can determine its accountability. To calculate the percentage of accountability use this formula. (Water Sold + Water Used, flushing, etc.)/Water Produced = % of Accountability

The retail water meter is a critical part of the distribution system and must be monitored and maintained. The meter is the cash register of the utility. In a typical water utility 12% of the customers use 50% of the water. It's important to review the usage patterns of these customers and to think preventive maintenance, which means establishing a meter maintenance program. Meters should be tested and repaired before there is a noticeable drop in consumption.

A water meter, like any other mechanical device, will wear out. As a meter wears out it generally slows down, or operates in the customer's favor, which means that the utility is not getting all of money that it is entitled to. It is extremely important that meters be tested for accuracy on a regular schedule.

The AWWA (American Water Works Association) Manual #6 – Water Meters-Selection, Installation, Testing, and Maintenance (4th edition, last updated in 1999) lists required testing periods and test requirements for all sizes and types of water meters. One of the tables that you will find in the manual is the periodic testing requirements of the various states Public Service Commissions. Indiana's rule is number 170 LAC 6-1. *see below*

5/8" & 3/4"	1"	1 ½" & 2"	3" and Larger
10 years	8 years	6 years	4 years

These are minimum recommendations. Meter testing expense should be looked at as a form of insurance. Spending a small portion of the revenue generated by the meter to ensure that it is working properly assures that the utility receives all of the revenue to which it is entitled. The best method of determining the frequency of testing is to look at the revenue generated by the meter.

Determine the percentage of a meter's annual revenue that is to be set aside for meter testing and the cost of a meter test. Take the meter's monthly revenue; multiply by the percentage of revenue set aside for meter testing. This gives a number, that when divided into the cost of a meter test, gives you the number of months between meter tests.

For example, a 3" meter that has an average monthly water and sewer bill of $400.00, and 3% of revenue is set aside for testing, and the cost to test a 3" meter is $250.00. Take the average monthly bill ($400.00) multiply by the percentage of set aside (3%). $12.00 is the monthly meter testing allotment. ($400*.03 = $12.00). Take the meter testing cost ($250.00) and divide it by the monthly meter testing allotment ($12.00) $250/$12.00 = 20.8. 20.8 is the number of months, say two years, between meter accuracy tests.

Displacement meters 5/8" through 2" are usually pulled (removed) from service and tested on a meter test bench. Compound and turbo meters can be pulled and tested. However, it is more efficient and more accurate to test the meters in place using a certified test meter or Pitot Rod. Testing in place is better because of the influence that the meter setting has on the meter. The configuration of the piping (elbows, tees, valves) creates turbulence in the pipe, which has an effect on the performance of the meter. A proper meter setting will have an inlet valve, test tee and outlet valve. Propeller and turbo meters require several pipe diameters of straight pipe (preferably ten) before and after the meter. This eliminates any turbulence.

When a meter is tested, it will either test within required accuracy limits or it will fail. If it fails a determination must be made whether to repair or replace the meter. In most cases a meter can be repaired. In some cases a meter cannot be repaired or cost of repair would exceed 50% of the cost of a new meter. In this case the meter probably should be replaced. This is the time to determine if the meter should be replaced with same size and type of meter or if there is a meter better suited to the application.

With so many types of meters available it's important to pick the correct size and type of meter for each metering application. Choosing which type of meter to use is not as difficult as selecting the correct size. Following are the typical applications for each type of meter normally used by a water utility:

Displacement meters and multi-jet meters are used for measurement of low and intermediate flows, like domestic use in residential applications. They are typically available in sizes from 5/8" through 2".

Turbo meters are used to measure intermediate and high flows like in a factory that uses high volumes of water, or to measure the water leaving the water plant. They are typically available in sizes from 2” through 20”.

Compound Meters are used where there is the need to measure both high and low flows, like in a hotel, school, or a commercial account where both domestic use and production use need to be measured by one meter. They are typically available in sizes from 2” through 6”.

Fire Service meters are used to measure water from fire lines. There are several types of fire line meters. Some measure all of the water going through the fire line in the event of a fire; these are typically large turbo meters.

Some only measure a portion of the water going through the fire line; this is called proportional metering. Some only measure low flows of water used when there isn’t a fire; these are called detector meters. There are also fire meters available that can measure both low flow domestic use and high flow fire fighting use. These are really large parallel type compound meters. They consist of a large turbo meter, a change over valve, and a 1 1/2” or 2” displacement or turbo meter to measure the domestic use.

Propeller meters are used to measure water from wells and water plants. They are used where there are no low or intermediate flows where the pumps are either on or off. They are typically available in sizes from 2” through 72”.

When selecting the type of meter to use in a particular customer’s application, it is very simple if adequate and reliable usage information is available. Selecting a replacement meter for an existing facility is somewhat easier then selecting a meter for a new facility. Talk to the customer and question them as to their anticipated water needs.

If the customer will only use water for domestic uses (drinking, bathing, washing, etc.) like a home, fast food restaurant, or bank, then install a displacement meter.

If the customer will only use water at intermediate or high flows (filling a tank for a batch process, irrigation system, wholesale metering) then a turbo meter should be installed.

If the customer will have multiple uses for water like a school where there are different water uses at different times of the day, from a single drinking fountain being used to dishwashers and restrooms being used during the lunch hour, then you a compound meter should be installed. When in doubt install a compound meter. An old rule of thumb for large facilities is that if someone sleeps there, and this includes apartment complexes, large office buildings and schools, install a compound meter.

Selecting the proper size of meter is more difficult then selecting the appropriate type of meter. Meter size generally does not equal service size. To determine the correct size of meter a fixture evaluation must be performed. To do this, use AWWA Manual 22 – Sizing Water Service Lines and Meters.

To perform a fixture evaluation, the number and types of water using devices are inventoried (counted and recorded). This means that every sink, shower, toilet, hose bib, washing machine, etc. is counted. The gallons per minute needed for lines supplying make up water, irrigation sprinkling zones and manufacturing process must be determined, along with the water pressure at the meter.

With this information and using the simple procedures in the M22, the customer's peak demand in gallons per minute can be estimated and the size of meter determined. In addition, after a facility has been inventoried, you will have the information you need to pick the type of meter that best fits the application.

There are several different types of registers available today to fit any application. Meters are provided with direct read registers unless some type of remote reading system is ordered. A direct read register has an odometer that the meter reader will record to get the meter reading. Registers are available in the Midwest to measure in Gallons or Cubic Feet. Different sizes of meters take different registers.

It is important that they not be mixed up. Just because it will fit doesn't mean it will work. Each size meter has a specific register; the internal gearing is designed to properly display the amount of water used for that particular size, brand and type of meter. The same is true of remote systems. Do not interchange remotes. Each size of meter has a designated remote with the appropriate number of fixed (non-moving) zeros.

It is important that the billing office have an accurate record of the number of fixed zeros on each water meter's register or remote. If a customer is billed for 10,000 gallons of water when they actually used 100,000 gallons, the customer is getting 90% of their water for free. If you are billing your customer for 100,000 gallons of water while they actually used 10,000 gallons then they are being billed 10 times too much. A zero is only a zero, unless it's on the end of a meter reading. Then it is a multiplier!

2.3.11.1.5 System Flushing

Water main flushing is performed to maintain water quality in the distribution system. Water quality is the number one goal of every water operator. If a distribution system cannot deliver high quality water or if there are problems in specific areas (i.e., discolored water, turbidity, high iron, etc., a water main flushing program can help alleviate those problems. A water utility is a business, and like any business, the primary goal is to deliver a high quality product effectively and efficiently. To determine a distribution system's functionality and ensure quality water is properly delivered, is not something that can be done overnight. It takes time, effort and desire. A water utility needs to follow a few basic, proven steps. These steps will allow any water utility to determine their distribution system's ability to provide high quality water on demand.

Prior to performing any type of flushing it is important to be aware of some of the hazards associated with flushing. System personnel need to be aware of where the flushing water will drain. In areas without curb and gutter, someone's house or garage can be easily flooded. Be aware of traffic and properly control it. Most importantly be aware of children. A flowing hydrant attracts children faster then an ice cream truck.

The proper tools are always needed: a good quality hydrant wrench that won't slip on the hydrant-operating nut, a Pitot Gauge to measure the pressure of the flowing water, a hydrant diffuser to dissipate the force of the flowing water and a hydrant port adapter with a gate valve to attach to the hydrant port prior to opening the hydrant. Diffusers that have a built in Pitot Gauge or diffusers that have a slot to insert the Pitot Gauge can be purchased from many suppliers.

Prior to flushing the hydrant adapter will need to be installed with the 2 ½" gate valve to the hydrant port. The use of this valve is strongly recommended. By using the valve to control the water flow from the hydrant, the possibility of creating a water hammer by opening or closing the hydrant too fast may be alleviated.

The hydrant must be opened completely or water will escape through the hydrant's weep hole. If water is leaking out of the weep hole, the ground around the hydrant will become saturated with water, thus not allowing the hydrant to drain properly, and the saturated ground can make the hydrant unstable if it is left leaking long enough. Therefore, if you need to open the hydrant completely to block the weep hole, then the only way to control the water flow from the hydrant is with the gate valve. Another equally important reason to use the gate valve is that in the event that a rock or something else flows into the hydrant during flushing, the flow of water can be stopped.

System personnel should be aware of how they stand while opening the hydrant. Back injuries are very common as a result of not standing properly and/or twisting the upper body while pulling on the hydrant wrench. Place the hydrant wrench on the hydrant and position the body so that the operator is standing parallel to the wrench. Grip the wrench with both hands and pull. If the hydrant operates smoothly so that the wrench can be turned with one hand, then the operator may step to the side and turn the wrench around the hydrant. If both hands are needed, pulling toward the operator to turn the hydrant wrench, then the operator should back up a step and pull the wrench toward the operator. Repeat this process backing around the hydrant until the hydrant is open or it starts to turn easily. This same procedure should be used to close the hydrant.

When flushing is finished, the hydrant must be completely closed. Close it snuggly then back it open ¼ turn. This prevents the hydrant stem from seizing. Once the hydrant is closed, make sure that the hydrant is draining properly. If the hydrant stands full of water it will freeze and break. To make sure that the hydrant is draining, hold a hand over the hydrant port, sealing it. While the hand is sealing the port, the water draining out the hydrant weep hole creates a vacuum in the hydrant. Seal the hydrant port with the hand for 30 seconds and then slowly lift the hand. If the hydrant is draining, suction will be felt on the hand.

Now is the time to remove all of the hydrant caps and grease them with non-water soluble food grade grease. A very light coating on the hydrant hose threads is all that's needed. The hydrant stem should also be lubricated.

Some hydrants have a grease fitting on the top; some have a plug that can be removed to access the fill hole for an oil reservoir. Consult your hydrant supplier for approved grease or oil.

When a customer calls and complains of poor water quality (taste, odor, or color) the complaint should be logged and marked on the distribution system map. A good way to do this is to keep a system map on a bulletin board and to use different color pushpins for different types of complaints. It's important to log all complaints so that flushing frequency can be adjusted based upon system complaints.

The entire distribution system does not need to be flushed each time a complaint is called in. Generally once a year is sufficient depending on your system water quality, but some parts of the distribution system may need to be flushed more frequently. It's possible that a dead end line may need to be flushed once a month.

When flushing in response to a customer complaint, perform a slow or low velocity flush. Flush enough water to clear the suspended particles, but at a low enough velocity to not stir up the particles that have settled out. Attach the control valve to one of the 2 ½" ports of the hydrant so that the flow can be throttled. With this type of flushing, a small segment of the distribution system will be flushed. This is a temporary fix. The same low flow characteristics that created the original customer complaint will over time cause the poor water quality to return. By tracking these complaints the frequency of flushing can be determined.

If flushing a dead-end every month eliminates all complaints, try flushing every two months. If there are no complaints, try every three months. The idea is to flush only as often as necessary. Flush often enough to keep the water quality good and yet be conservative enough as not to waste water.

When performing scheduled system flushing, plan each day's flushing sequence, starting at the source of supply or previously cleaned mains and working out into the distribution system. Flush from larger mains to smaller mains.

Once the flushing plan is established, it is time to notify the public and make them aware of what is being done, when it will be done and the areas that will be affected.

There are two types of scheduled system flushings that you can perform. Both have their advantages and disadvantages. The first is multi-directional (normal) flushing where valves are not operated. Hydrants are flowed starting at the source of supply. One hydrant is opened and another closed, always having a hydrant flowing. The disadvantage to this type of flushing is that, unless a dead end is being flushed, when a hydrant is flowed the water comes from both directions of the water main. Twice as much water may be needed to achieve the necessary velocity to clean the water main. The advantage is that valves need not be operated and artificial dead ends created. This is the least desirable method of flushing in regard to conservation.

The preferred method of flushing is unidirectional flushing. The disadvantage is that you have to have performed a main line valve-exercising program to ensure that valves work properly and that the distribution system map shows the correct placement of the valves. The advantage is that it conserves water. Valves are closed to create artificial dead ends. The necessary main cleaning velocity is obtained while flushing less water.

Generally, large supply mains will not have as much sediment as small mains. The velocity of the water moving through large mains is sufficient to keep all particles suspended. As the water enters the mains where there is less flow and a lower velocity the particles will settle out. This settling will occur at the tees where the low velocity mains tie into the high velocity mains. To clean the mains the water should be moving in the main at a minimum speed of 2.5 feet per second, 5 feet per second is optimal. The hydrant must be flowed long enough to thoroughly flush the main and to completely displace all of the water in that segment of main.

It is very important to keep a residual pressure gauge on another hydrant of the main being flushed to make sure that during the flushing of that particular length of main, the residual pressure does not drop below 20 p.s.i. If it does, it could mean that there is a partially closed valve, or the main may be closing up with encrusted scales.

To determine if the required flushing velocity has been achieved, the following chart that give examples for 500-foot sections of water main can be used:

MINIMUM FLUSHING VELOCITY @ 2.5 fps.

PIPE SIZE Diameter	*PIPE RADIUS* *in Ft.*	*PIPE AREA* *in Sq. Ft.*	*VELOCITY* *2.5 FPS*	*HYD PORTS* *2-1/2" Diameter*	*FLUSH TIME* *Minutes*	*AMT. FLUSHED* *Gallons*
4"	0.1666	0.08715	97gpm	1 port	3.33 min.	323.1 gals.
6"	0.25	0.19625	220 gpm	1 port	3.33 min.	732.6 gals.
8"	0.3333	0.3488191	390 gpm	1 port	3.33 min.	1298.7 gals.
10"	0.41666	0.5451214	610 gpm	1 port	3.33 min.	2031.3 gals.
12"	0.5	0.785	880 gpm	* 2 ports	3.33 min.	2930.4 gals.
16"	0.6666	1.39527	1565.5 gpm	* 2-4" ports	3.33 min.	5213.1 gals.

RECOMMENDED FLUSHING *VELOCITY @ 5 fps*

PIPE SIZE Diameter	*PIPE RADIUS* *in Ft.*	*PIPE AREA* *in Sq. Ft.*	*VELOCITY* *5 FPS*	*HYD PORTS* *2-1/2" Diameter*	*FLUSH TIME* *Minutes*	*AMT. FLUSHED* *Gallons*
4"	0.1666	0.08715	194 gpm	1 port	1.66 min.	323.1 gals.
6"	0.25	0.19625	440 gpm	1 port	1.66 min.	732.6 gals.
8"	0.3333	0.3488191	780 gpm	1 port	1.66 min.	1298.7 gals.
10"	0.41666	0.5451214	1220 gpm	* 2 ports	1.66 min.	2031.3 gals.
12"	0.5	0.785	1760 gpm	* 2 ports	1.66 min.	2930.4 gals.
16"	0.6666	1.39527	3131 gpm	* 2- 4" ports	1.66 min.	5213.1 gals.

* Can use Pumper port instead of two 2-1/2" ports

Once the required flow rate (gpm) is known to achieve the required velocity that must flow out of the hydrant, system personnel need to know how much water is in the main segment that is being flushed. The following formula allows one to calculate the volume of water that needs to be flushed/flowed from the water mains:

Unidirectional Flushing Math

This is the math formula for figuring the volume (in cu. ft.) of what is in the water main; as follows:

V = A x L

V = Volume in cu. ft.
A = (area in square ft.) = *x R (squared)*
R = radius of main (in feet)
= 3.14
L = Length of main (in feet)

<u>Example</u>: 500 ft. of 12" main has how many gallons of water in it?

V= A x L
V (cu. ft..) = [3.14 **x** (.5ft x .5ft.)] **x** 500 ft.
V (cu. ft..)= [3.14 **x** (.25 sq. ft.)] **x** 500 ft.
V (cu. ft..)= .785 sq. ft. **x** 500 ft.
V (cu. ft..)= 392.5 Cu. Ft..
1 cubic foot of water = 7.48 gallons of water.
V (g*allons*) = 392.5 cu. ft. **x** 7.48 gallons/cu. ft..
V (g*allons*) = 2935.9 gallons

*Please note that the <u>*radius*</u> of the main needs to be measured in feet, not in inches.

Therefore, 500 feet of 12" main has 2935.9 gallons of water in it. To flush this length of main @ 2.5 feet per second, divide 500 feet by 2.5 feet per second to get minimum time of flush (in seconds). Divide by 60 to get time in minutes.

500 feet divided by 2.5 feet per second = 200 seconds or 3.33 minutes.

2935.9 gallons divided by 3.33 minutes = 881.6 gallons per minute (for the flow rate) to get the *minimum flushing velocity* for the 12" main.

As long as the flow gauge on the diffuser is showing this flow rate or higher for the 12" main, everything should be OK. A better flow rate would be 5 feet per second or 1763.3 gallons per minute. In some cases, the flow rate may need to be as high as 7.5 feet per second or 2644.8 gallons per minute to create enough turbulence in the main to scour it clean.

The objective is to completely displace the total amount of water in the main and continue flushing until the water is clear. This will help conserve the amount of water being used during the flushing program but also will allow for a complete flush.

The flushing events for each segment of main need to be recorded. Log everything such as each valve that is closed (or opened), each hydrant that is flowed, any hydrant deficiencies, the flow rate (gpm) and the length of time that each hydrant was flowed. The flow rate and the length of time will allow a calculation of the daily total of the water used. By logging every event, they can be repeated the next time flushing is needed. When the project is completed, review the flushing program and its techniques, problems that occurred, any hydrants that need to be repaired and what corrective actions need to be taken.

An excellent reference for flushing is AWWA's publication – Maintaining Distribution-System Water Quality. It contains procedures for handling water quality complaints, the probable cause, and the solution.

2.3.11.2 Service Line Connections

Service line connections can be made when the water main is installed or years later. When a connection is made years later, a location of the water main must be determined. This can be accomplished by referring to the water map or record books. If maps and records have not been made or have been kept inaccurately, it may be necessary to locate the main by instruments.

Every effort should be made when excavating, installing and restoring are undertaken that the work not inconvenience the public or homeowner. Some utilities minimize their excavation by making use of boring or trenching machines. These are useful in developed areas with paved streets, curbs, and sidewalks.

Service lines should be protected form freezing.

1. The depth should be at least 4 feet of cover in southern Indiana and 5 feet in the central and northern part of the state.
2. Try to stay away from driveways and place the service line in the yard.

Service line material

1. Copper is the most common material for service lines
2. Plastic can also be used
3. Lead is no longer used because of health concerns
4. Brass has a very high cost
5. Galvanized has a problem with corrosion
   For industrial or commercial most service lines are ductile or cast-iron. This is because of the size of the line.

When sizing a service there are two major requirements.

1. Pressure loss is the controlling factor on proper service size
2. Flow rate at point of use is important most often in the bathroom

When installing the service line the utility must:

1. Locate all underground services
2. Make sure there is enough room to work
3. Have the correct shoring equipment
4. Make sure the thickness of the main is sufficient, if not:
   A. Use a saddle
   B. Replace bad section of main

Multiple taps

1. Small taps to make a large one
   A. Example 4 ¾” taps for a 1-1/2” service
2. Make sure there is enough room between taps so the water main is not weakened, at least 10” apart

After the service line is to the owner's property line, a curb stop should be installed. This allows the shut off of the water service if there is a leak, or for non-payment. When the curb stop is installed, turn on the corporation stop and flush off and pressurize the line, shut off the curb stop and place a curb box and rod over the curb stop, back fill and make sure the lid is to grade.

Always make record of what was done:

1. Location (address)
2. Size
3. What material was used
4. Map of curb stop

2.3.12 Safety

Safety is a matter of common sense, or is it? We can all think of things that we did when we were younger that were dangerous. Any unsafe act is dangerous. Probably at the time, we didn't realize how dangerous our unsafe act was. Not because we were stupid, but because we were ignorant. Ignorant of the potential hazards associated with our unsafe acts. Not stupid but ignorant, you might ask what's the difference? Quite simply, ignorance is curable, stupid is forever!

We can now look back and realize our mistakes and/or the risks that we took. Keep this in mind and ask yourself, what actions do we take today that are unsafe. Without proper safety training we are sometimes ignorant of the dangers associated with our actions. The cure for ignorance is education. We must become educated in the safety procedures that fit our daily activities.

We are only stupid if we are aware of the danger and hazards associated with an act and then choose to do it anyway. Disregarding the safe way to do something because it will take a little longer is stupid! Perhaps we'll be lucky, but what if we're not? What if we're killed, severely injured or permanently disabled? Will our family think that our short cut was worth it? What if it's an incident involving a co-worker and we're the ones that have to report the incident to their family. What will we tell them, "Well, he's dead, but got the job almost completed and in record time." If we take that one moment to consider the consequences, we don't mind taking the extra time to be safe.

A safety plan and training schedule must be developed to fit the activities, surroundings and OSHA (Occupational Safety and Health Administration) requirements. Each facility will have its unique characteristics. The utility cannot borrow a safety plan from a buddy or a neighboring utility and simply adopt it. One must be developed for every water system.
Read the OSHA standards (CFR 1910 general industry standards and CFR 1926 construction standards) to recognize that most everything that the standards cover are common sense items.

Following is a list of some of the safety areas in which a water operator should receive training; this list is in no way complete:

First Responder First Aid

> Personnel need training in what to do in the event that someone is hurt or injured. Personnel also need to learn how to survey the scene and be prepared to follow first aid ABC's.
>
> > **Airway** – Be certain airway is open
> > **Breathing** – Check for chest movement and air escaping from mouth and nose
> > **Circulation** – Check for pulse, and then control severe bleeding

Breathing and CPR (Cardiopulmonary resuscitation)

> When breathing stops from any cause (drowning, electric shock, suffocation, choking, poisoning) personnel need to know how to start mouth-to-mouth rescue breathing at once. Without a constant supply of oxygen, the brain begins to die within 4-6 minutes.
>
> If someone is down and doesn't have a pulse, personnel need to know how to react and administer CPR to provide blood circulation for the injured person.

Chlorine Safety

> If a utility does any type of chlorinating, personnel need to learn how to store and handle chlorine containers. Store chlorine containers in a cool place and protect them from exposure to external heat sources. Never permit the temperature of the contents to approach 140 degrees F. Keep containers that are stored out of doors away from direct exposure to the sun and the weather.

Maintain them in a clean condition and inspect them regularly for leakage. Do not store containers near flammable materials, or where continuous exposure to dampness will result.

Make certain that the storage area is well ventilated and that the containers are so arranged that a leaking unit could be removed with the least possible handling of other containers. Arrange to use a fireproof storage room equipped with an exhaust ventilating system. Place containers in the order in which they are received so that the oldest can be used first.

Confined Space

Federal Law requires that every place of employment establish a "Confined Space Entry and Rescue Plan". A "confined space" is a space having limited means of entry or exit, and so enclosed that adequate ventilation cannot be obtained. Any space with limited access and limited ventilation shall be considered dangerous until tested and evaluated according to SAFE GUIDELINES.

A space that meets all of the following criteria is considered to be a confined space:

- It is large enough and so configured that an employee can bodily enter and perform assigned work.
- It has limited or restricted means for entry or exit.
  (meter vaults and pits generally have limited means of entry)
- It is not designed for continuous employee occupancy.
  (these are spaces which are entered only for periodic cleaning, inspection and maintenance)
  Before a confined space is entered the following tests will be made to ensure that the space is safe to enter.
- Check the atmosphere using a multi-gas gas detector, and check the confined space to see if it is safe.
- Check the Oxygen content of the space to ensure that it is between 19.5% and 23.5%.
- Check for the presence of flammable and toxic gases.
- Look at the confined space. Is it structurally safe? Does it have converging walls or a sloping floor?

Fall Protection

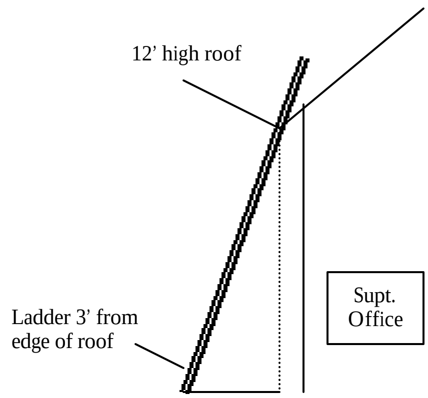
Personnel need to learn the hazards associated with working above the floor and how improper safety equipment can cause serious injury. Learning to assess the work area and make an educated decision as to the type of safety equipment needed saves lives and prevents serious internal injuries in the event of a fall.

Ladder Safety

Everyone knows how to use a ladder. However, every year people are injured from falls when misusing ladders. Learn the common sense safety rules for using ladders, which include the following:

- Place the ladder on a firm base; always face the rungs when climbing up or down the ladder.
- Do not extend the height of a ladder with boxes or concrete blocks; get a longer ladder.
- Do not use metal ladders near live, exposed electrical circuits.
- Open step ladders fully so that the spreaders lock into position.
- Do not use stepladders as straight ladders.
- Do not place ladders on slanting, oily, or slippery surfaces; if absolutely necessary to do so, secure the ladder thoroughly or have it held by another employee.
- Remove tools and materials from the top and pail shelves before moving the ladder.

- Make sure that straight ladders are properly placed for safe use.
- Secure all straight ladders at the top and bottom. Straight ladders must extend at least three (3) feet above the landing.
- Use two people when handling long extension ladders.
- Do not use a ladder at a ratio (pitch) of over 4 to 1. The 4-to-1ratio applies to the distance the ladder's base must be from the foundation. This is figured by dividing the length of the structure from the ground to the top support point (where the ladder rests against the building) by four.



- Do not climb higher than the second rung from the top on stepladders, or the third rung from the top on straight ladders.
- Protect wooden ladders with a clear coating in lieu of an opaque paint.
- Do not use the ladders in horizontal position as scaffolding.
- Protect ladders set up in alleyways, walkways, and roadways.

Lifting and carrying

Test the weight and handling carefully prior to attempting to lift an object. Consider the size, weight, and shape of the object to be carried. Do not lift more than can be handled comfortably. If necessary, get help. Set feet solidly. One foot can be slightly ahead of the other for increased effectiveness. Feet should be far enough apart to give good balance and stability (approximately the width of the shoulders). Get as close to the load as practicable. Bend legs about 90 degrees at the knees. Do not squat.

It takes about twice as much effort to get up from a squat. Bend knees. Keep the back as straight as practicable. It may be far from being vertical, but it should not be arched. Bend at the hips, not from the middle of the back. Grip the object firmly. Maintain the grip while lifting and carrying. Before changing or adjusting this grip, set the object down again. Straighten the legs to lift the object, and at the same time bring the back to a vertical position.

A good tip is to look up at the sky or ceiling when beginning a lift. Never carry a load that you cannot see over or around. Make sure the path of travel is clear. Carry the object close to the body. Never turn at the waist to change direction or to put an object down. Turn the whole body and crouch down to lower the object. Grip the object firmly, keep it close, and keep the back straight (not arched). To keep hands from being pinched against the floor, put one corner of a box or similar object down first, so that the fingers can be removed from under the sides.

Lockout – Tag Out

A Lockout – Tag Out program is necessary for anyone who works on any type of equipment. Quite simply it is the application of a lock to the energy source for a piece of equipment to prevent that equipment from accidentally being energized while it is out of service for repair or maintenance.

PPE (personal protection equipment)

Suitable approved personal protective equipment shall be used whenever required by instructions or when it provides greater safety. Personal protection equipment includes: Hard Hat, Goggles, Safety Glass, Gloves, Hearing Protection, Steel Toed Shoes, Body Harness. A PPE plan must be written for each type of job.

Respirator Safety

Anyone who may need to wear a respirator needs to know the proper way to fit and wear it and how to handle and care for the air tanks and hoses. A respirator is necessary for those employees that may have to repair a chlorine leak or enter a permit required confined space that has a hazardous atmosphere.

Traffic Control & Flagging

All projects within the road right-of-way are subject to highway requirements. Employees exposed to vehicular traffic should be provided with and should be instructed to wear warning vests marked with or made of reflectorized or high visibility material. Everyone working in the road or near the road needs to know the proper way to place safety cones to route traffic away from the workers. Personnel must learn when to close a lane and when to close the road.

Proper flagging techniques are important so that motorists are not confused by the hand signals given and the flagger is not in danger from oncoming traffic.

Trenching and Shoring

Learning the proper techniques for evaluating an open excavation is important; people die every year from cave-ins. Before opening any excavation, personnel need to determine if there are underground utilities in the area.

The determination of the angle of the slope of the excavation and design of the supporting system shall be based on careful evaluation of pertinent factors such as: depth of cut; possible variation in water content of the material while the excavation is open; anticipated changes in materials from exposure to air, sun, water, or freezing; loading imposed by structures, equipment, overlying material, or stored material; and vibration from equipment, blasting, traffic, or other sources.

Special precautions shall be taken in sloping or shoring the sides of excavations adjacent to a previously back-filled excavation or a fill, particularly when the separation is less than the depth of the excavation. Particular attention also shall be paid to joints and seams of material comprising a face and the slope of such seams and joints.

If it is necessary to place or operate power shovels, derricks, trucks, materials, or other heavy objects on a level above and near an excavation, the side of the excavation shall be sheet-piled, shored, and braced as necessary to resist the extra pressure due to such superimposed loads.

Sides of trenches in unstable or soft material, 5 feet or more in depth, shall be shored, sheeted, braced, sloped, or otherwise supported by means of sufficient strength to protect the employees working within them.

In trenches over 4 feet deep, workers must be provided with steps or ladder within 25 feet for quick escape.

Receiving training in these areas make sense. Some of these items are covered in AWWA's (American Water Works Association) Operator School. The Operator School syllabus includes: Safety of handling chemicals, Safety of working with chlorine, Safety of trenching and pipe installation, Safety at the job site, Safety of hydrant installation, operation and flushing, and a chapter on electricity including safety.

There are numerous places to receive safety training. A trainer can be hired to come to a utility or personnel can attend classes sponsored by one of the water or waste water associations like AWWA, IRWA (Indiana Rural Water Association), AIRW (Alliance of Indiana Rural Water), IWEA (Indiana Water Environment Association), or APWA (American Public Works Association).

Many of the companies that sell safety equipment also offer training. Make sure that training is received from a certified trainer and not someone who just seems to know what they're talking about.

After the events of September 11th, 2001, the safeguarding of water supplies must be considered. The FBI considers the water systems in America to be under threat from terrorists. The threat is real! Doors must now be locked that had never been locked before. Wells, reservoirs, water towers and pumping stations must be secured.

In the past, if doors and gates to our facilities were locked, it was to keep the kids out, to prevent spray painting and vandalism. Now all operators and system owners must be aware that there are those who wish to do much more than vandalize.